Title: Running Hot and Cold

Brief Overview:

> This lesson is a demonstration of the affects of temperature on dexterity. Students will develop hypotheses about how temperature affects dexterity. They then will be asked to perform a simple task while their hand is submerged in cold water, and again in warm water. Students will collect their own data from the experiment and perform a statistical analysis on the data with respect to the aforementioned hypotheses.

Links to NCTM Standards:

- **Mathematics as Problem Solving**
  Students will demonstrate their ability to devise a hypothesis, gather their own data, and use statistics to compare their findings with their hypotheses.

- **Mathematics as Communication**
  Students will demonstrate their ability to communicate mathematically through the use of data and the statistical analysis of the data to make a valid conclusion about their hypotheses.

- **Mathematics as Reasoning**
  Students will demonstrate their ability to reason through the development and justification of their hypotheses.

- **Statistics**
  Students will demonstrate their ability to collect, organize, analyze, and display the data collected throughout experiment. They also will demonstrate their understanding of the process of hypothesis testing through the analysis of the data.

- **Probability**
  Students will demonstrate their understanding of probability through the discussion of probability distributions and how they relate to the test being performed with respect to the null and alternative hypotheses.

Grade/Level:

> Grade 11-12

Duration/Length:

> This activity should take two class periods including assessment.

Prerequisite Knowledge:

> Students should have working knowledge of the following skills:

- The concepts that underlie the process of hypothesis testing
- Paired difference t-tests
- The concept of Type I error, the probability of Type I errors, and p-values
- The concept of degrees of freedom associated with a statistical test

Objectives:

Students will:

- be able to analyze scientific data to determine whether temperature affects dexterity.
- be able to conduct similar tests on paired data in future labs.

Materials/Resources/Printed Materials:

- 2-4000 mL beakers
- 2-50 mL beakers
- Ice
- 40 pennies (approx.) or similar objects

Development/Procedures:

- Students will perform the lab experiment according to the given procedures. They should begin with cold water for each student, and continue with warm water freshly obtained to ensure equal conditions for each student. It may be necessary to replenish the ice every few trials.
- Students should collect data for the entire class throughout the experiment, i.e., the number of pennies successfully transferred in the warm water and the number of pennies successfully transferred in the warm water.
- Before proceeding to the analysis, students should first condense their data into a single column of differences, that is for each student, compute the difference between the number of pennies successfully transferred in the warm water and the number of pennies successfully transferred in the cold water. (Note that some values may be negative if more pennies were successfully transferred in the cold water.)
- Treating this column of differences as a single data set, students first need to compute the mean and standard deviation of the differences. Using these values, students should compute the associated t-value and the degrees of freedom associated with this t-value. Students should then look up their value in the t-table to find the associated p-value.
- Based on this, students should draw conclusions about their original hypotheses and thus the effects of temperature on dexterity.

Performance Assessment:

Students will be assessed in a following lab when they will be required to conduct the same statistical tests on the data collected. The students will be scored according to the rubric included.

Extension/Follow Up:

- If this lesson is used in an exclusively scientific classroom, you may choose to require only certain students to perform these tests in future labs. This unit could function as a pure enrichment if desired.
- The students should use their knowledge of statistical analysis of data in any future lab with paired data. The same rubric should be used to ensure the students' awareness of expectations.

- Possible lab experiments that would lend themselves to these statistical tests include: Measuring the vital lung capacity of each student using a spirometer, calculating the normal lung capacity using sex, age, and height or researching the values, and comparing the sets. Comparing the normal heart rates of students to heart rates after consuming caffeine or chocolate or physical exercise.

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Running Hot and Cold

Background

Have you ever tried to take off your shoes after you have come in from a cold day? Did you encounter any problems? We have unique dexterity in our hands due to their rich supply of nerve endings and our wide range of movements. They are certain factors that can affect that dexterity, one of which we will explore today.

Objective

To investigate the effect of temperature on dexterity

Materials

2-4000 mL beakers   2-50 mL beakers
20 pennies (approx.) for each beaker Ice

Procedure

1.   Fill both the 4000 mL beakers about 2/3 full of tap water. In one, use lukewarm water, and cold water with ice in the other. Put the pennies on the bottom of each 4000 mL beaker and place a a 50 mL beaker on the bottom, open side up, in each.

2.   One person should place their hand in the cold water for 15 seconds. Then they have 15 seconds to put as many pennies as they can in the beaker. YOU CAN ONLY PUT THEM IN ONE AT A TIME! Record each person's time.

3.   Next each person should put their hand in the warm water for 15 seconds. Then they have 15 seconds to put as many pennies into the beaker. Record each person's time

Questions for Analysis/Discussion

1.   What effect does temperature have on your ability to put pennies in the beaker?

2.   What effect does the cold water have on the blood supply to your hands?

3.   What kind of extreme temperatures would astronauts be exposed to?   How do they protect themselves?

Running Hot and Cold Data

Name of Student	Pennies in Cold Water	Pennies in Warm Water	Difference

Statistical Analysis Scoring Rubric

3 Analysis of data shows complete understanding of statistics and related scientific concepts.

2 Analysis of data shows some understanding of statistics and related scientific concepts.

1 Analysis of data shows little or no understanding of statistics and related scientific concepts.